U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-290 715

Attainment and Maintenance of Sulfur Dioxide Standards in Puerto Rico

Engineering-Science, Inc, McLean, VA

Prepared for

Environmental Protection Agency, New York Region II

Oct 78

PB 290715

EPA·902/4·78·005

Attainment and Maintenance of Sulfur Dioxide Standards in Puerto Rico

Final Report

October 1978

REPRODUCED BY
NATIONAL TECHNICAL
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U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION II
PUERTO RICO ENVIRONMENTAL QUALITY BOARD

ANALYSIS OF SULFUR DIOXIDE AIR QUALITY IN PUERTO RICO

Submitted to

U. S. Environmental Protection Agency
Region II Offices
New York, N. Y.

AND

Puerto Rico Environmental Quality Board
Santurce, Puerto Rico

Submitted by

Engineering-Science
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October 1978

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CHAPTER I

INTRODUCTION

BACKGROUND

The recent Clean Air Act Amendments of 1977 called for the participation of local, state, and Federal air pollution control officials to meet ambient air quality standards as expeditiously as possible, and to establish plans for the coming years to deal with the maintenance of clean air levels. As a result of this Contressional mandate, Engineering-Science (ES) has been engaged by the U. S. Environmental Protection Agency (EPA) to assist the Puerto Rico Environmental Quality Board (EQB) in conducting an engineering analysis of sulfur dioxide levels in Puerto Rico. This study is being conducted concurrently with another analysis underway for particulate matter.

STUDY YEARS

This study is concerned with the predictions of sulfur dioxide air quality levels in Puerto Rico for the years 1976 and 1990. Emission inventories for the base year for both point and area sources had been compiled in previous studies completed by ES. This data base was recently updated using information provided by EQB in October 1977. Growth estimates for the projection year were obtained from industry and government officials and represent the best estimates of future industrial production and domestic activity on the island.

STUDY AREAS

The areas analyzed in this study were determined previously by EPA and ES as having the potential for exceeding the air quality standards for sulfur dioxide. These areas are listed below and appear in Figure 1-1.

FIGURE I-1

STUDY AREAS

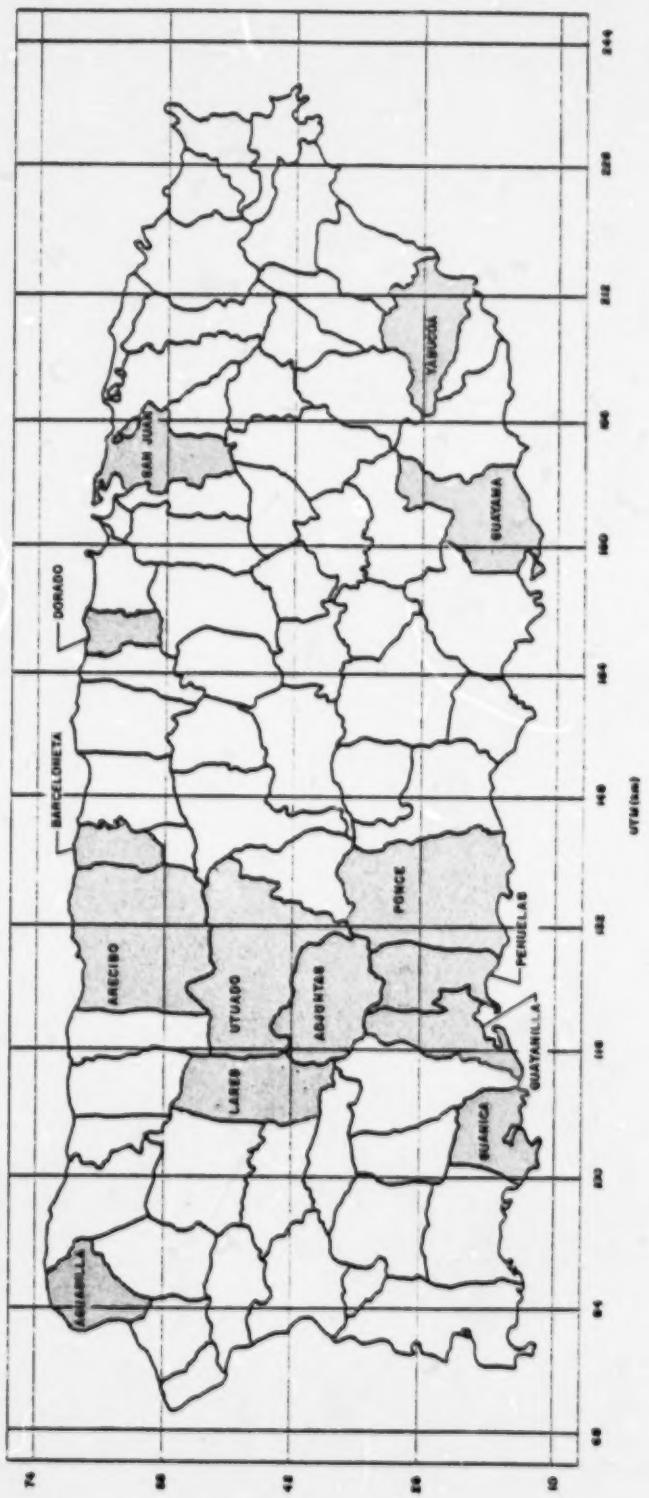

TABLE 1-1

STUDY AREAS

Aquadilla	Guayanilla-Penuelas
Arecibo-Braceloneta	Lares-Utuado-Adjuntas
Dorado	Ponce
Guanica	San Juan
Guayama	Yabucoa

METHODOLOGY

EPA's dispersion model, AQDM, was used together with emission and meteorological data to predict sulfur dioxide levels in each of the study areas, including most of the SO_2 monitoring stations presently operated by EQB. Concentrations were predicted for both the base case and 1990. Source category contributions[1] to air quality at the locations of maximum concentration were determined through an analysis of the AQDM contribution file. This will help in the development of SO_2 control strategies by indicating what type sources contribute the most to SO_2 levels. Concentration isopleths were drawn from data obtained using a grid of receptors over most of the island.

ORGANIZATION OF REPORT

Chapter I has dealt with the presentation of background information and the introduction to the analysis. Chapter II concerns the development of the emission inventories and Chapter III presents the discussion of results. A report summary is provided in Chapter IV.

All tasks involved in the completion of this study were performed by the staff of Engineering-Science, McLean, Virginia. The report is a scientific and impartial evaluation of SO_2 air quality in Puerto Rico and does not reflect or advocate any particular position of view by the authors.

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[1] The term 'source category contributions' refers to the air quality level directly associated with a specific category of emission sources. Such information is extremely valuable in developing strategies to reduce emissions.

CHAPTER II

EMISSION INVENTORIES

POINT SOURCE INVENTORIES

The point source inventory used in this analysis was developed in October 1977 and was the result of a series of updates that were undertaken by EQB as part of their routine file maintenance procedure.[1] The completed file was judged by EQB to reflect operating conditions existing in 1976, and represent the most current SO_2 emission inventory.

Basically the point source file consists of some 5,000 computerized records, forming a standard file on more than 600 plants or companies, with individual process description and stack data for over 1,500 emission points. The information was arranged in EIS/P&R format and was easily processed using standard CDHS programs.

Important SO_2 emission categories in the point source file were steam boilers and petroleum process heaters.

AREA SOURCE INVENTORY

The inventory consisted of information on a municipality level related to emission categories such as commercial/institutional and light industrial fuel use, open burning and traffic. Some municipalities such as San Juan, Ponce, and Mayaguez had been sub-divided to provide an added level of detail. The information had been compiled by ES under a previous study.[2]

The SO_2 emission category which had the highest emission in the area source file was fuel combustion for light industrial processes.

---

[1] EQB uses the EIS/P&R computer data handling system to maintain data on emissions and plant operating characteristics.

[2] Puerto Rico Air Quality Maintenance Planning and Analysis, Base Year Evaluation and Projections, Engineering-Science, 1976.

SUMMARY OF EMISSIONS BY SOURCE CATEGORY

Individual points in EIS/P&R inventories are characterized by an eight-digit Source Classification Code (SCC) assigned by agency personnel when source information is entered into the computer file. Each SCC represents a specific function within a broad source category. Classification of sources by their SCC enabled several source categories to be analyzed with regard to emissions in the base case and for the study year 1990.

Projection of emissions from the base case to 1990 were handled by assuming that all growth occurred in place. Growth factors obtained from industry personnel and questionnaires, or government forecasts were then applied to base emissions.

Specific growth information was available from three major industries on the island: sugar processing, asphalt batching, and power generation. The indication from asphalt and sugar companies was that there would be no growth in total output in terms of emissions over the period. The power company plans to satisfy increasing demand, projected to 1990 to be about 180% of 1976 levels, by increasing output from existing stations, at least until 1988. Specific factors were also available from mineral processing industries (rock handling, storing) and beverage manufacturers. The selection of a growth factor for the asphalt, pharmaceutical, and food processing industries was based on Island-Wide Population Projections.[1] For all other sources a factor of 4.5% per year increase was used reflecting the growth in Gross National Product expected through 1985.[2] Table II-1 presents the factors used to project the 1976 emissions to 1990 levels.

The 1990 scenario must really be considered a worst case analysis. The scenario does not consider the effect of an offset policy, nor does it consider the fact that some of the new emissions will likely be spread out at

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1 Puerto Rico Planning Board, Social Planning Bureau.

2 U. S. Industrial Outlook, 1976, with Projections to 1985, U. S. Dept. of Commerce, Domestic and International Business Administration, Bureau of Domestic Commerce, January 1976.

TABLE II-1

SUMMARY OF GROWTH FACTORS FOR PUERTO RICO

2-DIGIT SIC GROUP		FACTORS FOR PERIOD 1976 TO 1990
20	Food - kindred products	1.94
	2051 Bread	1.25
	2052 Cookies Crackers	1.25
	2061 Cane Sugar	1.00
	2062 Cane Sugar Refining	1.00
	2082 Malt Liquors	1.84
	2085 Distilled Liquors	1.84
	2095 Roasted Coffee	1.25
21	Tobacco	1.94
22	Textile Mill Products	1.94
23	Apparel and finished products	1.94
24	Lumber and wood products	1.94
25	Furniture	1.94
26	Paper and allied products	1.94
27	Printing, publishing etc.	1.94
28	Chemicals and allied products	1.94
	2834 Pharmateutical Preparations	1.25
29	Petroleum refining	1.94
	2951 Paving mixtures and blocks	1.00
	2952 Asphalt felts and coatings	1.25
30	Rubber and miscellaneous plastic products	1.94
31	Leather and leather products	1.94
32	Stone, clay and glass products	1.94
	3271 Concrete block and brick	1.15
	3272 Concrete products	1.15
	3273 Ready-mixed concrete	1.15
	3281 Cut stone	1.15
	3295 Minerals and earths	1.15
33	Primary metals	1.94
34	Fabricated metal products except machinery	1.94
35	Fabricated metal products machinery	1.94
36	Electrical machinery equipment	1.94
37	Transportation equipment	1.94
38	Professional scientific instruments	1.94
39	Miscellaneous manufacturing (all others)	1.94
4911	Electric Companies	1.80

new plant sites. The scenario does not account for the fact that these new emissions may have to meet new source performance standards if a new unit is built to accommodate the increase in demand for a product. For the 1990 scenario we have assigned all new emissions to existing emission sites, which will tend to make predicted concentrations higher than actually expected.

In the point source master file there were about 365 points with emissions of sulfur dioxide greater than, or equal to one ton per year. Total island-wide point source emissions of particulate matter were estimated at about 290,000 tons per year. Because of the preponderance of small sources only those point sources emitting over 5 tons per year were modeled in order to avoid costly dispersion model computer runs. The remaining sources, numbering about 80 and representing about 162 tons per year, were combined with the area source emissions from the nearest municipality. Furthermore, three separate areas of the island were analyzed individually. For each maintenance area, the corresponding emission inventory and meteorological data were used. The study areas considered were the geographic portions of the island listed in Table II-2 and illustrated in Figures II-1 through II-3; some degree of overlap occurs. Tables II-3 through II-5 give the municipalities included in each study area.

TABLE II-2

STUDY AREAS

GEO-LOCATIONS	RECORDING SITE FOR METEOROLOGICAL DATA	NUMBER OF POINT SOURCES MODELED OVER 5 TONS PER DAY	NUMBER OF SURROUNDING MUNICIPALITIES MODELED
Northeast Quarter	Isla Verde	126	40
Northwest Quarter	Ramey AFB	61	33
Southern Half	Santa Isabel	148	55

TABLE II-3

MUNICIPALITIES INCLUDED IN THE

NORTHEASTERN STUDY AREA

SAROAD CODE	NAME	SAROAD CODE	NAME
0140	Aguas Buenas	1280	Humacao
0320	Barceloneta	1420	Juncos
0360	Barranquitas	1520	Las Piedras
0400	Bayamon	1560	Loiza
0480	Caguas	1580	Luquillo
0517	Canovanas	1620	Manati
0540	Carolina	1740	Morovis
0580	Catano	1780	Naguabo
0640	Ceiba	1820	Naranjito
0680	Ciales	1860	Orocovis
0720	Cidra	2020	Rio Grande
0800	Comeria	2160	San Juan
0840	Corozal	2200	San Lorenzo
0880	Dorado	2300	Toa Alta
0940	Fajardo	2320	Toa Baja
0960	Florida	2340	Trujillo Alto
1140	Guaynabo	2420	Vega Alta
1180	Gurabo	2460	Vega Baja

FIGURE II-1

PUERTO RICO
NORTHEASTERN STUDY AREA

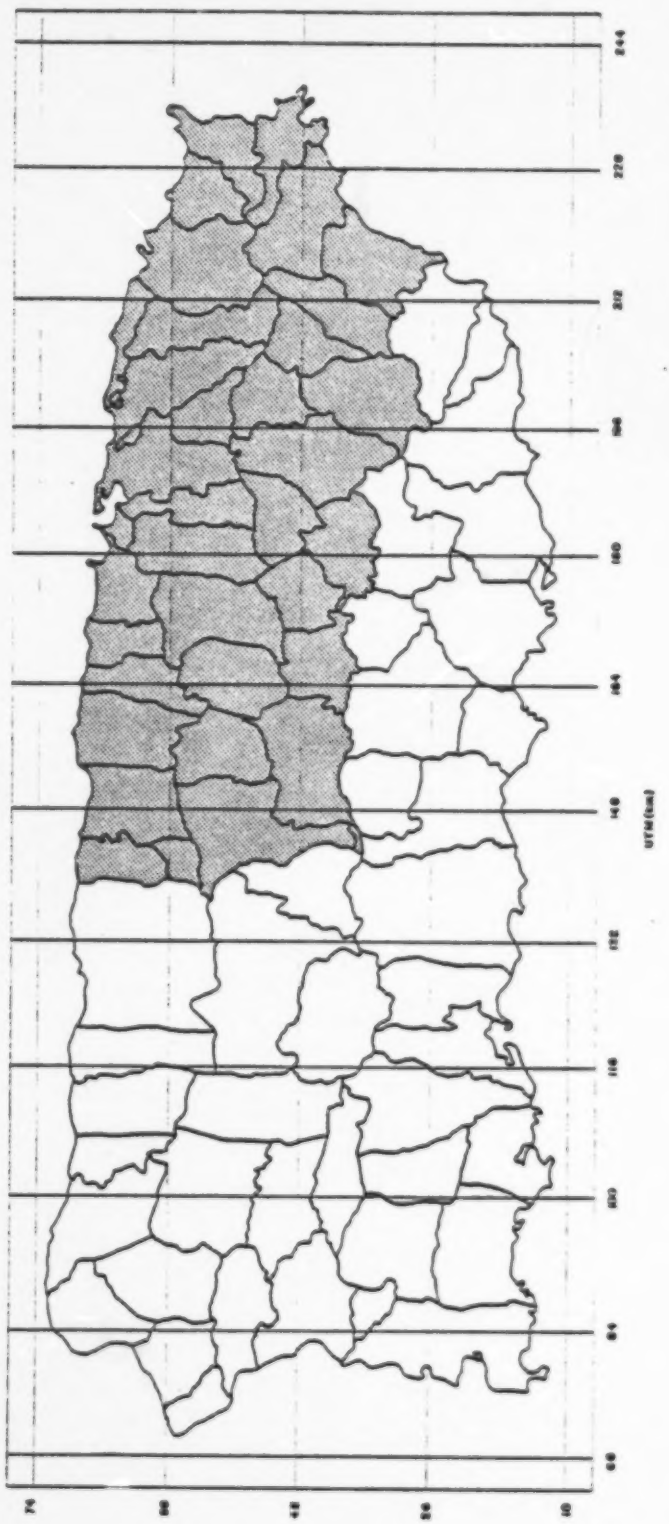


TABLE II-4

MUNICIPALITIES INCLUDED IN THE

SOUTHERN STUDY AREA

SAROAD CODE	NAME	SAROAD CODE	NAME
0040	Adjuntas	1520	Las Piedras
0180	Aibonito	1640	Maricao
0280	Arroyo	1660	Maunabo
0360	Barranquitas	1700	Mayaguez
0440	Cabo Rojo	1880	Patillas
0620	Cayey	1900	Penuelas
0720	Cidra	1940	Ponce
0760	Coamo	2060	Sabana Grande
1020	Guanica	2080	Salinas
1060	Guayama	2120	San German
1100	Guayanilla	2200	San Lorenzo
1240	Hormigueros	2280	Santa Isabel
1280	Humacao	2500	Villalba
1340	Jayuya	2540	Yabucoa
1380	Juana Diaz	2580	Yuaco
1440	Lajas		

FIGURE II-2

PUERTO RICO
SOUTHERN STUDY AREA

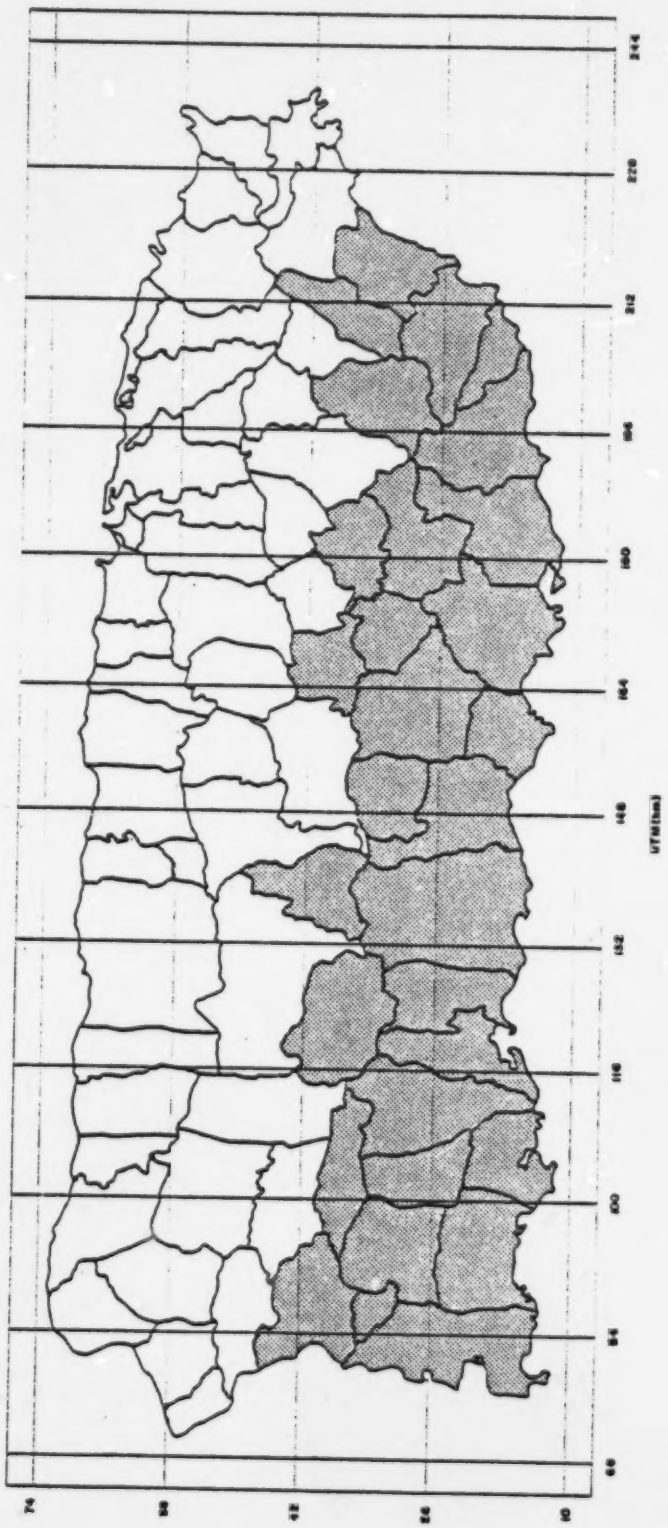


TABLE II-5

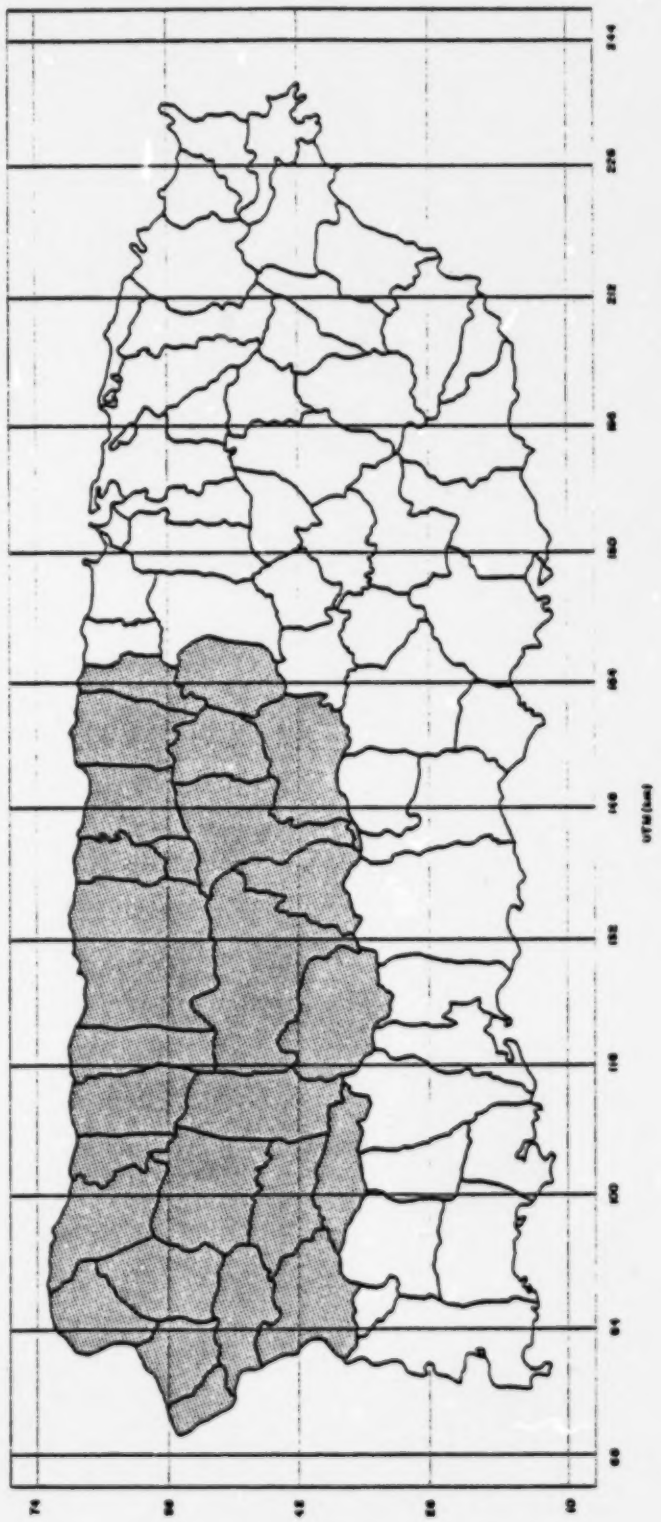
MUNICIPALITIES INCLUDED IN THE

NORTHWESTERN STUDY AREA

SAROAD CODE	NAME	SAROAD CODE	NAME
0040	Adjuntas	1480	Lares
0080	Aguada	1500	Las Marias
0120	Aguadilla	1620	Manati
0200	Anasco	1640	Maricao
0240	Arecibo	1700	Mayaguez
0320	Barceloneta	1720	Moca
0500	Camuy	1740	Morovis
0680	Ciales	1860	Orocovis
0840	Corozal	1960	Quebradillas
0960	Florida	1980	Rincon
1220	Hatillo	2240	San Sebastian
1240	Hormigueros	2380	Utuado
1320	Isabela	2420	Vega Alta
1340	Jayuya	2460	Vega Baja

FIGURE II-3

PUERTO RICO
NORTHWESTERN STUDY AREA



The emissions for the three separate study areas are summarized in Tables II-6 through II-8 by major emission source category. For point sources, the highest emissions were observed from external combustion boilers.

TABLE II-6

SOURCE CATEGORY EMISSION CONTRIBUTIONS
STUDY AREA: NORTHWESTERN

SOURCE CATEGORY	CONTRIBUTIONS - TONS/DAY BASE	1990
Area Sources	12.9	23.1
Boilers	18.7	29.0
Turbines	13.1	23.5
Petroleum Process Heaters	-	-
Process and Other Heaters	1.6	2.2
Incineration	0.8	1.0
TOTAL	47.1	78.8

TABLE II-7

SOURCE CATEGORY EMISSION CONTRIBUTIONS
STUDY AREA: SOUTHERN

SOURCE CATEGORY	CONTRIBUTIONS - TONS/DAY BASE	1990
Area Sources	25.7	46.3
Boilers	339.3	613.4
Turbines	31.3	56.8
Petroleum Process Heaters	72.3	140.3
Process and Other Heaters	4.5	6.9
Incineration	0.2	0.3
TOTAL	473.3	864.0

TABLE II-8

SOURCE CATEGORY EMISSION CONTRIBUTIONS

STUDY AREA: NORTHEASTERN

SOURCE CATEGORY	CONTRIBUTIONS - TONS/DAY BASE	1990
Area Sources	37.8	68.1
Boilers	246.0	439.4
Turbines	16.5	29.6
Petroleum Process Heaters	7.0	13.6
Process and Other Heaters	29.0	55.3
Incineration	1.7	2.8
TOTAL	338.0	608.8

CHAPTER III

DISCUSSION OF RESULTS

MODEL CALIBRATION

Sulfur dioxide monitoring data for 1976 were available for 9 sites in Puerto Rico. One of the first steps in the analysis, after emission inventory preparation, was to use EPA's Air Quality Display Model (AQDM) to estimate the concentrations of SO_2 at these sites for comparison with measured data. The comparison is used to validate the model and also develop a calibration factor. In this case the comparison resulted in a gross difference between the predicted value and the measured value. At most sites, predicted mean concentrations were 3 times the measured concentration. Because of this, ES did not use a calibration factor for adjustment of predicted concentrations for any of the study areas. All monitoring used gas bubblers which have been known to be unreliable at times, yielding ambient concentration values lower than those from continuous monitoring units. The comparison between measured and predicted concentration appears in Table III-1. The Puerto Rico and Federal Air quality standards for SO_2 are:

- Primary Standard 80 $\mu g/m^3$ annual arithmetic mean
- Secondary Standard 60 $\mu g/m^3$ annual arithmetic mean[1]

ISLAND-WIDE PREDICTIONS

Emission and meteorological data files were developed for three separate geographic areas of the island. This approach was justified since the island has distinct characteristics of rugged terrain at its center, affecting dispersion, and since meteorological data were available from three locations. In a previous report published by ES,[2] an analysis of the variations in meteorological data was made between the San Juan, Ponce, and Ramey sites. Specific data concerning emissions have been discussed in Chapter II.

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[1] Suggested guideline.

[2] Puerto Rico Air Quality Maintenance, Planning and Analysis, Base Year Evaluation and Projections, Engineering-Science, 1976.

TABLE III-1

COMPARISON OF MEASURED AND
PREDICTED SO_2 AIR QUALITY

MONITORING SITE	CONCENTRATIONS - $\mu g/m^3$ MEASURED[a]	PREDICTED[b]
San Juan	7	23
Bayamon	8	53
Catano - Las Vegas	8	71
Guaynabo - Ft. Buchanan	9	48
Toa Baja	7	67
Ponce	6	15
Guayanilla - Plaza	7	26
Guananilla - Magas Arriba	7	33
Penuelas	7	9

[a] SO_2 was measured using the gas bubbler

[b] The model predicted concentration with no calibration factors applied, i.e. slope = 1.0 and background = 0.0 $\mu g/m^3$.

Table III-2 summarizes some additional SO_2 data collected for the January through August 1977 period. These measurements were from continuous monitoring used around a large oil fuel power plant. The higher concentration observed occurred at monitors which were sufficiently above the plant elevation. The predicted concentration for this area ranged from about 50 to 70 $\mu g/m^3$, annual basis. These few data points tend to validate the use of a dispersion model like AQDM to predict SO_2 levels throughout the Commonwealth.

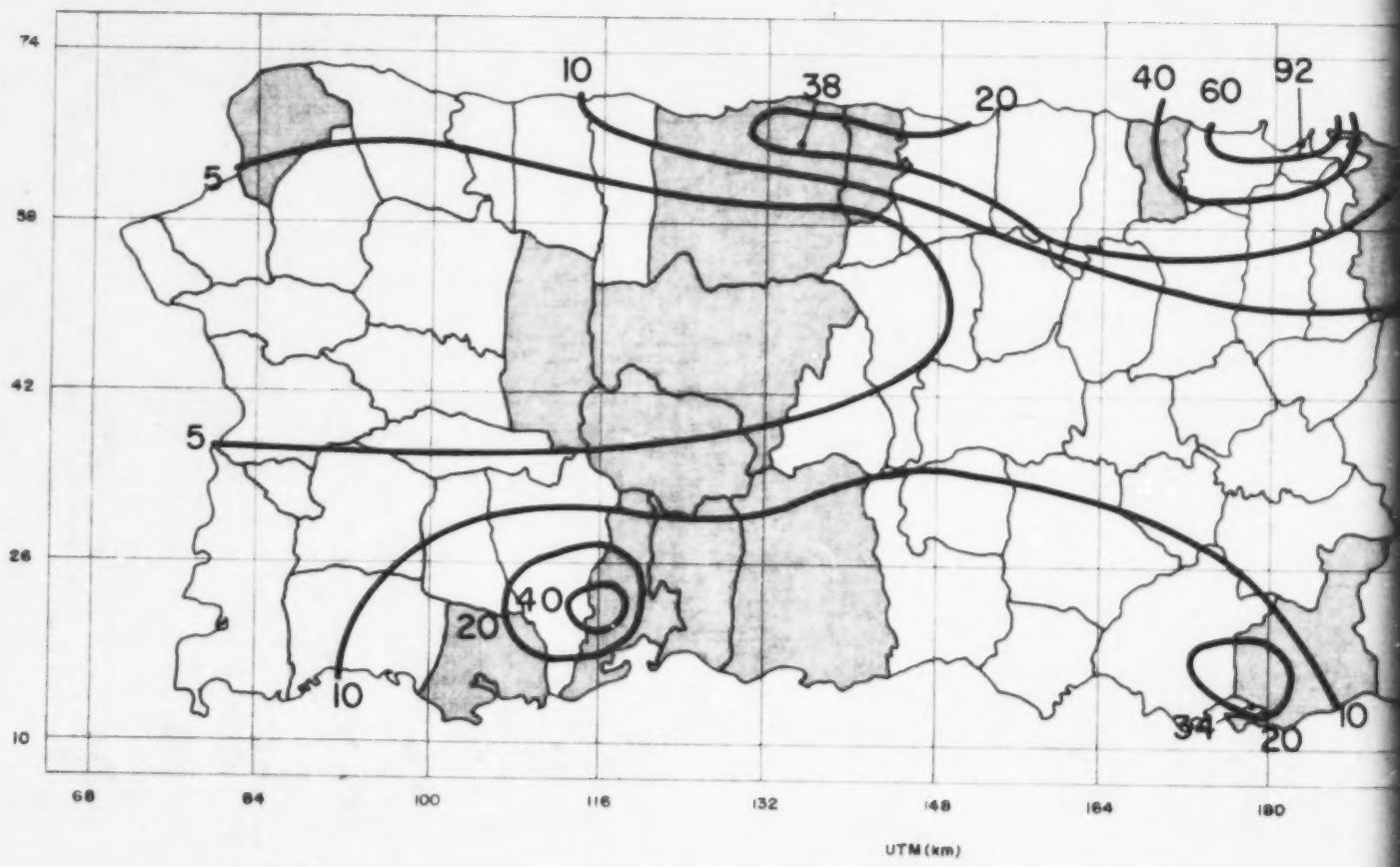
EPA's AQDM was used to predict ambient SO_2 concentration over the three portions of the island, covering all study areas. In general, a four-by-four kilometer grid spacing was used for receptor locations. A one-by-one grid spacing was used in Catano. Concentration isopleths were then drawn using the concentrations predicted for each grid point. Two cases were analyzed: actual operating conditions for the base year 1976, and projected operating conditions for 1990. For the 1990 case, emissions were assumed to grow unconstrained at existing emission sites; new source location were not considered. The isopleths for the base year and 1990 appear in Figures III-1 and III-2.

Centers of industrial activity on the island were apparent with the coincidence of high SO_2 concentrations. In general, these were the Catano, Guayanilla, Guayama, and Yabucoa areas. Other regions of the island showed somewhat less activity in emissions and ambient SO_2 levels. The highest concentration on the island was predicted to occur in Catano with a value of 92 $\mu g/m^3$ annual basis. This value exceeds the primary standard of 80 $\mu g/m^3$. No other study areas were found to exceed the primary standard. By 1980, however, it is expected that three study areas will exceed the primary standard. Even considering our 1990 analysis as "worst case" situation, it appears that control strategies will have to be implemented to reduce SO_2 emissions as the primary standard will be exceeded. New amendments to the EQB's Article VI regulation covering sulfur dioxide emission from virtually every stack on the island can be used to "readjust" the allowable SO_2 emission such that air quality standards will never be exceeded. However, this approach will require an accurate emission inventory on an annual basis for not only point sources but area sources as well.

Concentrations in the base case are above the standard in Catano, and close to the secondary standard in some other areas. With any industrial growth at

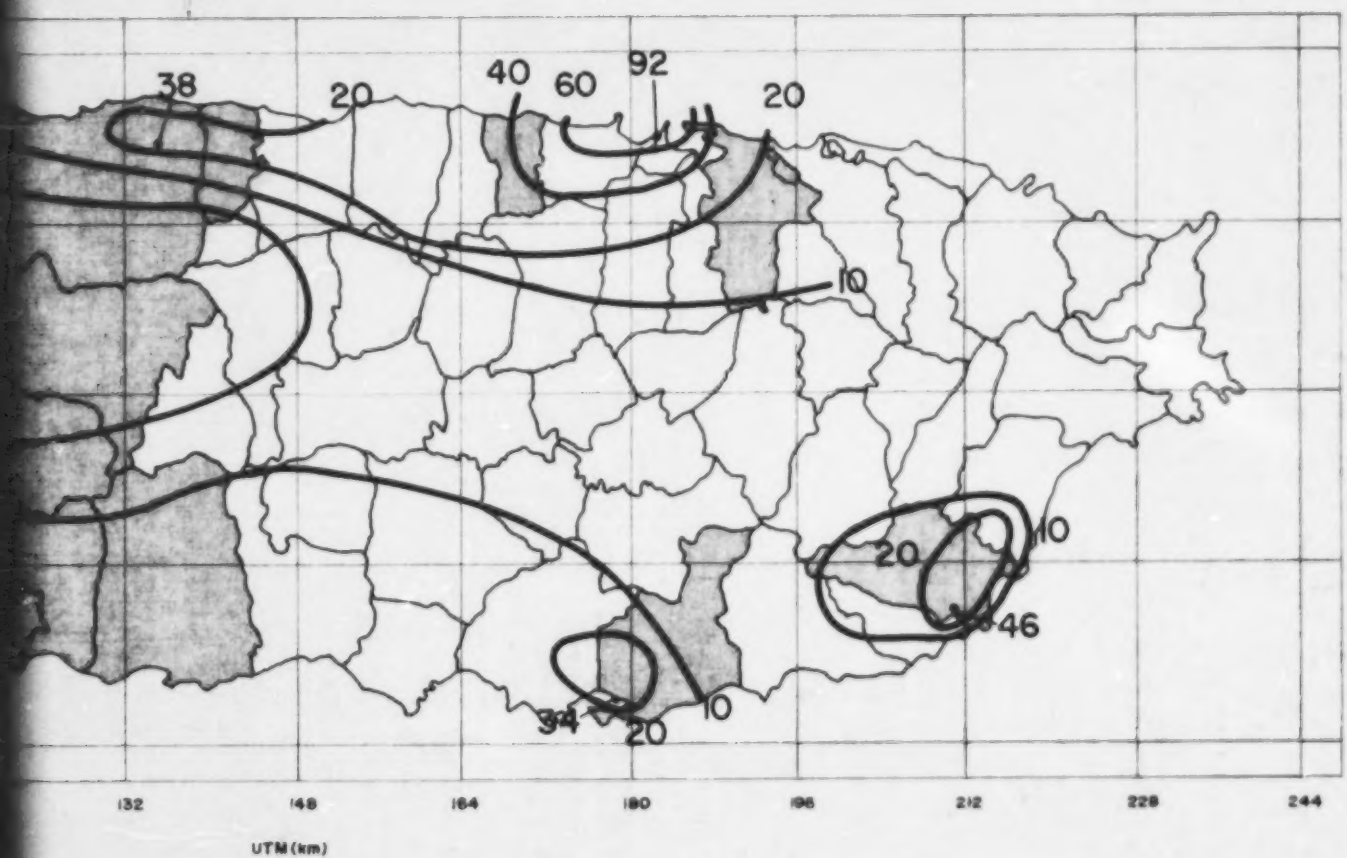
ANNUAL AVERAGE SO_2 CONCENTRATIONS $\mu g/m^3$ ARITHMETI

BASE YEAR



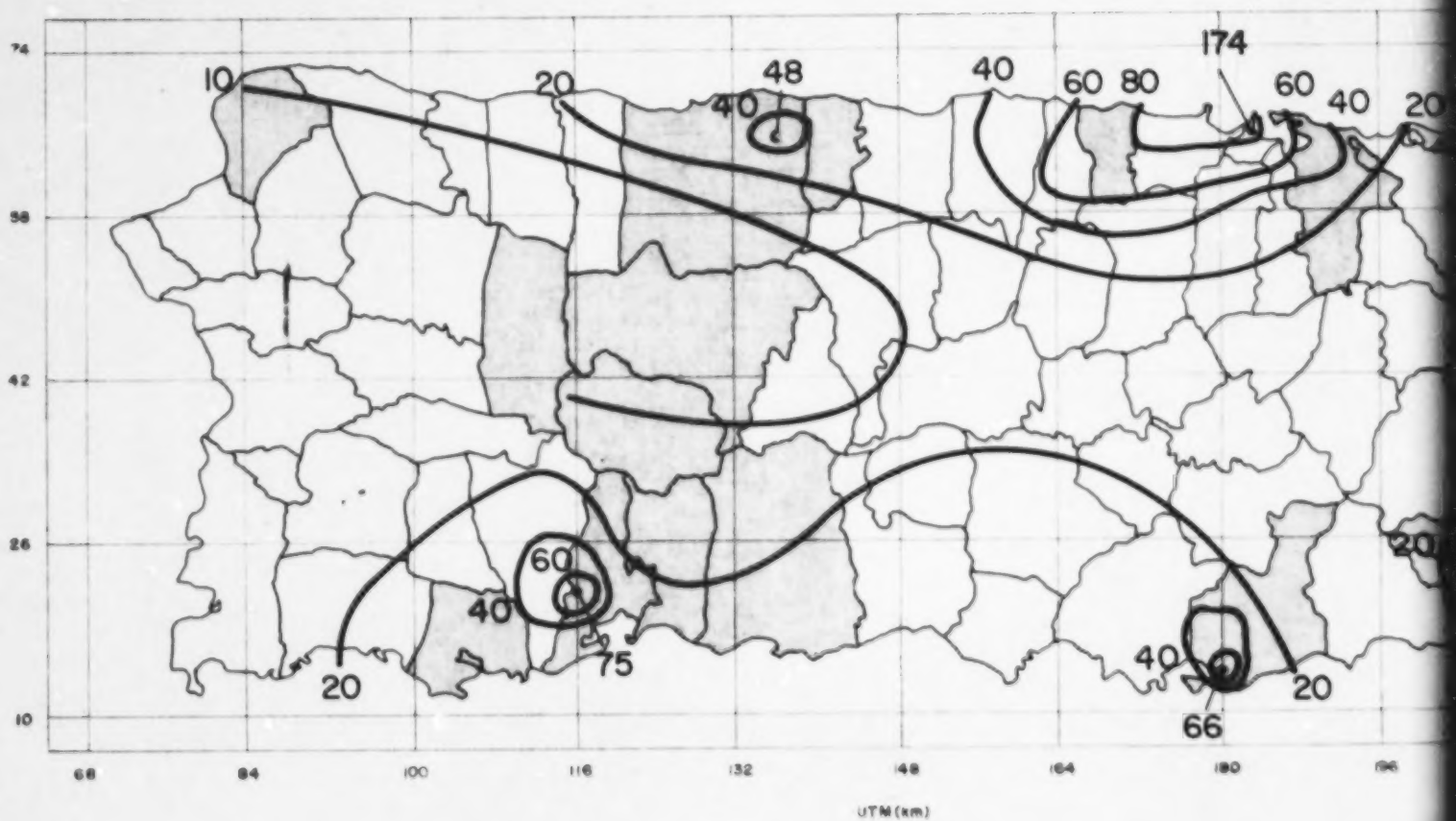
AVERAGE SO_2 CONCENTRATIONS $\mu g/m^3$ ARITHMETIC MEAN

BASE YEAR



ANNUAL AVERAGE SO_2 CONCENTRATIONS - ug/m^3 ARITHMETIC MEA

1990



L AVERAGE SO_2 CONCENTRATIONS - $\mu g/m^3$ ARITHMETIC MEAN

1990

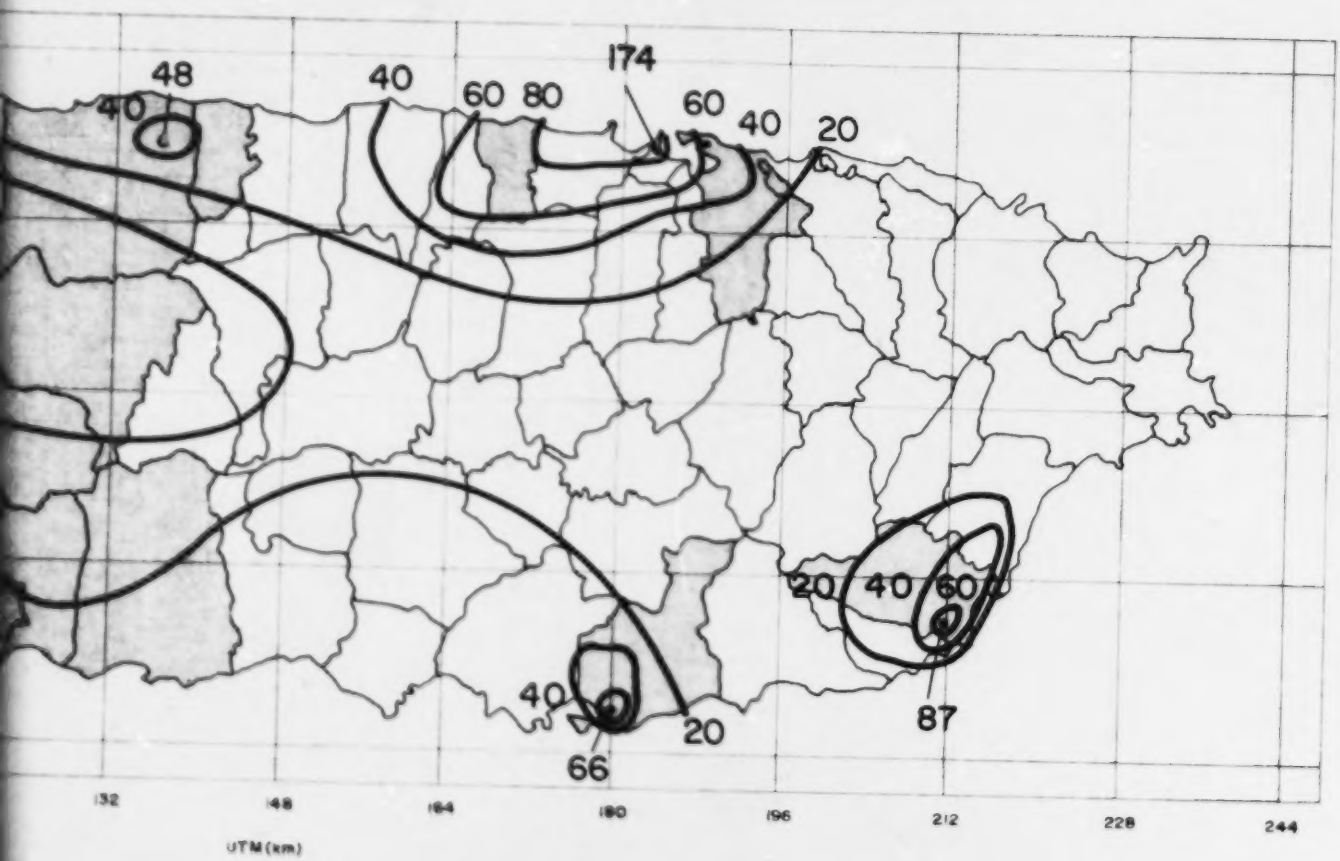


TABLE III-2

ADDITIONAL SO_2 CONTINUOUS MONITORING DATA FOR THE GUAYANILLA AIR BASE[a]

	SO_2 CONCENTRATION ($\mu g/m^3$)		
	JAN-AUGUST 1977	3-hour Max.	24-hour Max.
Mario Mercada Hill	49	630	181
Mario Mercada Castle	50	629	236
Corco	84	1072	307
Guayanilla Plaza (Port Authority Bldg.)	14	118	55
Magas Arriba (Eugenia M. Hastos School)	11	147	84
Magas Abajo	21	233	63
Stella Hill	24	270	79
Guayanilla (Government Center)	6	94	37

[a] The predicted SO_2 concentration for this area ranged from about 50 - 70 $\mu g/m^3$, annual basis. No micro scale modeling was completed for these monitors.

all, concentrations will continue to increase unless emissions are reduced at the same time. One method that can be used to accommodate growth is through the emission offset policy, which requires that new sources reduce emissions from an existing plant by an amount equal to or greater than the amount they intend to add.

SOURCE CATEGORY CONTRIBUTIONS

If control strategies are to be effective, they must deal with the emission sources of greatest importance. For each of the maximum concentration receptors indicated on the isopleth map of Figure III-1, the contributions to the predicted concentration have been tabulated by source category. Contributions were also determined for the same receptors for the 1990 case. Tables III-3 through III-7 present the contributions from area sources, boilers, turbines, manufacturing processes, process heaters, and incinerators using auxiliary fuel. It appears that the categories with the greatest contribution are external combustion boilers and process heaters. These categories account for more than 50% of the total predicted air quality level at each of the maximum sites.

INDIVIDUAL STUDY AREA ANALYSIS

Ambient concentrations were predicted for the 10 study areas of interest listed in Chapter I. Maximum concentrations in each area are presented in Table III-8. Of the ten, only one indicated concentrations exceeding the primary standard while all others showed SO_2 levels within the secondary standard. For the 1990 conditions analyzed, five areas are expected to exceed the secondary standard, while three show average values exceeding the primary standard. Certainly EQB must plan ahead in order that air quality standards will be maintained. The Clean Air Act requires that the states revise their plans to show maintenance of the standards. This must be accomplished through emission limitations. Probably the most effective means of insuring emission reductions over the long term will be the application of Article VI or an emission offset policy.

TABLE III-3

SOURCE CATEGORY CONTRIBUTIONS TO PREDICTED AIR QUALITY AT THE LOCATION OF MAXIMUM CONCENTRATION

STUDY AREA: Northwestern

MUNICIPALITY: Arecibo

UTM LOCATION: 136.0 66.0

SOURCE CATEGORY	CONTRIBUTIONS - $\mu g/m^3$ BASE	1990
Area Sources	3.1	5.6
Boilers	18.0	25.6
Turbines	1.6	0.5
Petroleum Process Heaters	0.0	0.0
Process and Other Heaters	8.5	9.4
Incineration	5.2	6.5
TOTAL	36.4	47.6

TABLE III-4

SOURCE CATEGORY CONTRIBUTIONS TO PREDICTED AIR QUALITY AT THE LOCATION OF MAXIMUM CONCENTRATION

STUDY AREA: Southern

MUNICIPALITY: Guayanilla

UTM LOCATION: 116.0 22.0

SOURCE CATEGORY	CONTRIBUTIONS - $\mu g/m^3$ BASE	1990
Area Sources	9.7	17.4
Boilers	23.4	43.6
Turbines	0.6	1.0
Petroleum Process Heaters	5.1	9.8
Process and Other Heaters	0.5	0.9
Incineration	0.0	0.0
TOTAL	39.3	72.7

TABLE III-5

SOURCE CATEGORY CONTRIBUTIONS TO PREDICTED AIR QUALITY AT THE LOCATION OF MAXIMUM CONCENTRATION

STUDY AREA: Southern
MUNICIPALITY: Guayama
UTM LOCATION: 180.0 14.0

SOURCE CATEGORY	CONTRIBUTIONS - $\mu g/m^3$ BASE	1990
Area Sources	5.6	10.0
Boilers	8.6	16.5
Turbines	0.1	0.2
Petroleum Process Heaters	20.0	38.9
Process and Other Heaters	0.1	0.1
Incineration	0.0	0.0
TOTAL	34.4	65.7

TABLE III-6

SOURCE CATEGORY CONTRIBUTIONS TO PREDICTED AIR QUALITY AT THE LOCATION OF MAXIMUM CONCENTRATION

STUDY AREA: Southern

MUNICIPALITY: Yabucoa

UTM LOCATION: 212.0 22.0

SOURCE CATEGORY	CONTRIBUTIONS - $\mu g/m^3$ BASE	1990
Area Sources	2.2	4.0
Boilers	0.4	0.7
Turbines	0.0	0.1
Petroleum Process Heaters	41.5	80.5
Process and Other Heaters	0.8	1.6
Incineration	0.0	0.0
TOTAL	44.9	86.9

TABLE III-7

SOURCE CATEGORY CONTRIBUTIONS TO PREDICTED AIR QUALITY AT THE LOCATION OF MAXIMUM CONCENTRATION

STUDY AREA: Northeastern

MUNICIPALITY: Catano

UTM LOCATION: 183.0 65.0

SOURCE CATEGORY	CONTRIBUTIONS - $\mu g/m^3$ BASE	1990
Area Sources	18.0	32.2
Boilers	69.1	132.0
Turbines	0.2	0.3
Petroleum Process Heaters	0.8	1.4
Process and Other Heaters	3.5	6.8
Incineration	0.9	1.8
TOTAL	92.5	174.5

TABLE III-8

MAXIMUM SO_2 CONCENTRATIONS
IN DESIGNATED STUDY AREAS

STUDY AREA	MAXIMUM CONCENTRATIONS - $\mu g/m^3$ BASE YEAR	1990
Aguadilla	5	10
Arecibo - Barceloneta	38	48
Lares - Utuado - Adjuntas	5	10
Guanica	21	39
Guayanilla	40	75**
Ponce	19	33
Guayama	34	66**
Yabucoa	46	87*
Dorado	49	89*
San Juan (Catano)	92*	174*

* Exceeds both the primary and secondary standards.

** Exceeds the secondary standard.

CHAPTER IV

SUMMARY AND CONCLUSIONS

1. Engineering-Science used the EPA's AQDM to estimate existing ambient SO_2 levels in 10 study areas of Puerto Rico.

2. Due to the unsuitability of air monitoring data, the AQDM could not be validated and no calibration factor was used to adjust predicted concentrations.

3. Groundlevel concentrations exceeding the primary SO_2 standard of 80 $\mu g/m^3$ were predicted in only one study area, Catano.

4. Emissions were projected to 1990, assuming unconstrained in place growth. Growth factors were available from industry and government.

5. Concentrations were predicted for the 1990 case in the same 10 study areas. The results indicated that three study areas would be exceeding the primary standard and that two others would exceed the suggested secondary standard guideline of 60 $\mu g/m^3$.

6. Contributions to maximum concentrations were presented to identify source categories most responsible for the high concentrations. These contribution tables should be used to develop cost effective control strategies.

7. Suggested control strategies are a stricter limit for sulfur in fuel in those areas where standards have the potential to be exceeded by use of EQB's Article VI regulation on SO_2 emission.

8. An emission offset policy could also be used to prevent further degradation of the ambient air quality.